4.7 Interface Management (Satisfies criteria of EIA/IS731 FA 1.5 and iCMM PA 7)

4.7.1 Introduction to Interface Management

Interface Management, which includes identification, definition, and control of interfaces, is an element of System Engineering (SE) that helps to ensure that all the pieces of the system work together to achieve the system's goals and continue to operate together as changes are made during the system's lifecycle. Precise interface definition early in the program is crucial to a successful and timely development. As the total system is decomposed into functional areas, interfaces (functional and/or physical) between the areas are identified. These interfaces are typically characterized by functional data parameters with associated data requirements or mechanical, electrical, and space requirements. Functional and physical interface requirements are contained in the appropriate performance specifications. The Interface Management process enters the Acquisition Management System (AMS) process at the end of the first phase of Investment Analysis and continues through In-Service Management. The essential elements of the Interface Management process are illustrated in Figure 4.7-1, which lists the key inputs necessary to initiate the task, providers, process tasks, outputs required, and customers of process outputs. The beginning and ending boundary task intermediate tasks are detailed later in the section.

Process: Perform Interface Management	**ID No.:** 4.7 (iCMM PA 07) **Date:** April 25, 2000 **Revision Date:** September 30, 2004
Next Higher Level Process: Perform System Engineering	**Process Owner:** System Engineering Council

Process Objective:

Achieve functional and physical compatibility between all interrelated product elements.

Inputs

a) Requirements
b) CONOPS
c) Architectures (functional/physical)
d) Functional I/F list
e) IPP
f) FAA policy, Standards
g) Trade study reports
h) Interface change request
i) Approved Baselines, Approved Baseline Changes, Configuration Status Accounting Report

Providers

a) RM
b) FA
c) FA, Syn
d) FA, IM
e) ITP
f) EXT
g) TS
h) EXT
i) CM

PROCESS TASKS

Beginning Boundary Task

Identify interfaces

- Analyze functional interfaces
- Analyze physical interfaces
- Create N^2 diagram
- Prepare scope sheets
- Develop IRDs
- Write ICDs
- Revise IRD and ICD as necessary

Ending Boundary Task

Control interfaces

Lifecycle Phase

- [x] Mission Analysis
- [x] Investment Analysis
- [x] Solution Implementation
- [x] In-Service Management
- [x] Service Life Ext.
- [ ] Disposal

Outputs

a) I/F requirements documents
b) Interface control documents
c) Interface revision proposal
d) Concerns/issues
e) Change Requests
f) Configuration Documentation

Customers

a) V&V, CM, RM, EXT, Syn
b) V&V, CM, RM, EXT, Syn, SpecEng, FA
c) CM
d) RSK
e) CM
f) CM

Figure 4.7-1. Interface Management Process-Based Management Chart

4.7.1.1 Interface Management Objectives

The objective of Interface Management is to identify, describe, and define interface requirements to ensure compatibility between interrelated systems and between system elements, as well as provide an authoritative means of controlling the interface design.

The Interface Requirements Document (IRD) controls interface requirements and the Interface Control Document (ICD) controls interface design. These documents:

- Define and illustrate physical and functional characteristics in sufficient detail to ensure compatibility of the interface so that this compatibility shall be determined from the information in the IRD/ICD alone
- Identify the necessary interface data and monitor submission of this data
- Control the interface requirements and design to prevent any changes to characteristics that might affect compatibility with other systems and equipment
- Communicate coordinated interface requirements and design decisions, as well as interface requirements/design changes to program participants

4.7.1.2 Types of Interfaces

An interface is any external or internal boundary between one element and another that is physical or functional. Internal interfaces are within the defined system's boundary. External interfaces are with elements outside the defined system's boundary. The external/internal interface distinction relates to the level of ownership and the verification of the requirements associated with each interface. Examples of interface types that may be encountered appear in Table 4.7-1. The 5M and SHELL Models (Figures 4.7-2 and 4.7-3, respectively) depict the types of interface elements that are recommended for consideration within most systems. Each element of the system shall be described functionally and physically. A functional description describes what the system is intended to do. It includes subsystem functions as they relate to and support the system function. The Functional Analysis section 4.4 provides more information on this topic. A physical description provides information on the composition and organization of the tangible system elements. The level of detail varies with the system's size and complexity, with the end objective being adequate understanding of the system configuration and operation. The Synthesis Section 4.5 provides more information on synthesis alternatives.

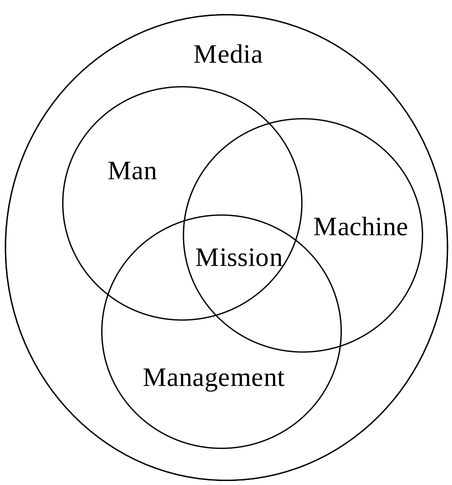
Table 4.7-1. Examples of Interface Types

Interface Type	Interface Subtype	Examples
Functional	Mechanical	Vehicle operator increasing speed A computer sending a document to printer
Physical	Mechanical	Transmission of torque via a drive shaft Connection between computer communication port and the printer cable
Functional	Control	A control signal sent from a flight control computer through a cable to an actuator (two interfaces) A human operator selecting a flight management system

Interface Type	Interface Subtype	Examples
		mode
Physical	Control	The connection between the flight control computer and the cabling A human operator's fingers adjusting a flight management system mode switch
Functional	Aerodynamic	Pilot notification of a stall Vortices impacting on an aircraft
Physical	Aerodynamic	A stall indicator on a wing A fairing designed to prevent vortices from impacting a control surface on an aircraft
Functional	Environmental (Natural or Induced)	Maximum/minimum temperature of radar electronics The amount of rain/snow that makes a sensor reading anomalous
Physical	Environmental (Natural or Induced)	Increased volume of mercury in thermometer reaching new markers on temperature scale Wind impacting radar antenna surface
Functional	Noise	Minimum decibels required for an alert to be heard
Physical	Noise	Sound waves impacting on person's ear drum
Functional	Space	Space required to perform maintenance
Physical	Space	Inserting hardware into existing rack
Functional	Data	A cockpit visual display to a pilot Weather Message Switching Center Replacement (WMSCR) to Weather and Radar Processor (WARP) data transfer
Physical	Data	Light from cockpit visual display impacting on pilot's retina Weather data bits moving from communications cable to communications port on WARP
Functional	Electrical	Energy from a direct current (DC) power bus supplied to an anticollision light A fan plugged into an alternating current (AC) outlet for current An electrical circuit opening a solenoid Shielding and grounding for coaxial cables
Physical	Electrical	Energy from a DC power bus supplied to the cabling connected to the anticollision light Electrical current moving from AC outlet to fan wire Current flowing through wiring Shielding material wrapped around copper wiring

Interface Type	Interface Subtype	Examples
Functional	Hydraulic	Pressurized fluid supplying power to a flight control actuator A fuel system pulling fuel from a tank to the engine
Physical	Hydraulic	Pressurized fluid in a hydraulic line Connection of fuel line to fuel tank
Functional	Pneumatic	An adiabatic expansion cooling unit supplying cold air to an avionics bay An air compressor supplying pressurized air to an engine air turbine starter
Physical	Pneumatic	Pressurized air in an aircraft
Functional	Electromagnetic	Radio frequency (RF) signals from a Very High Frequency Omni directional Range (VOR) A radar transmission
Physical	Electromagnetic	RF signals from a VOR vibrating radio receiver Radio waves emitted from radio transmitter
Functional	Heating, Ventilating, and Air-Conditioning (HVAC)	Amount of heating and cooling required for a facility Circuit protective devices for equipment racks
Physical	HVAC	Thermocouple contacting sensor Circuit breaker connection to power line

5M Model of a System



- Mission: Central function or purpose
- Man: Human element
- Machine: Hardware & Software
- Management: Policies, procedures & regulations
- Media: Environment-ambient & operational

Figure 4.7-2. Depiction of 5M Interface Model

The following is a description of the 5M Interface Model:

- **Mission:** the purpose or central function of the system that brings together the other elements.
- **Man:** the human element of a system. If a system requires humans for operation, maintenance, or installation, this element shall be considered in the system description.
- **Machine:** the hardware and software (including firmware) element of a system.
- **Management:** the procedures, policy, and regulations involved in operating, maintaining, installing, and decommissioning a system.
- **Media:** the environment in which a system shall be operated, maintained, and installed. This environment includes ambient and operational conditions. Ambient conditions are physical conditions involving temperature, humidity, lightning, electromagnetic effects, radiation, precipitation, and vibration. Operational environment consists of the conditions in which the mission or function is planned and carried out. Operational conditions are human-created conditions involving operations such as air traffic density, communication congestion, workload, and Instrument Flight Rules (IFR) versus Visual Flight Rules (VFR). Part of the operational environment may be described by the type of operation (e.g., air traffic control, air carrier, general aviation); phase (e.g., ground taxiing, takeoff, approach, en route, transoceanic, landing); or rules governing the operation (e.g., IFR, VFR).

In the SHELL Model, the match or mismatch of the blocks (interface) is just as important as the characteristics described by the blocks themselves. These blocks may be rearranged to describe the system as required. A connection between two blocks indicates an interface between the elements.

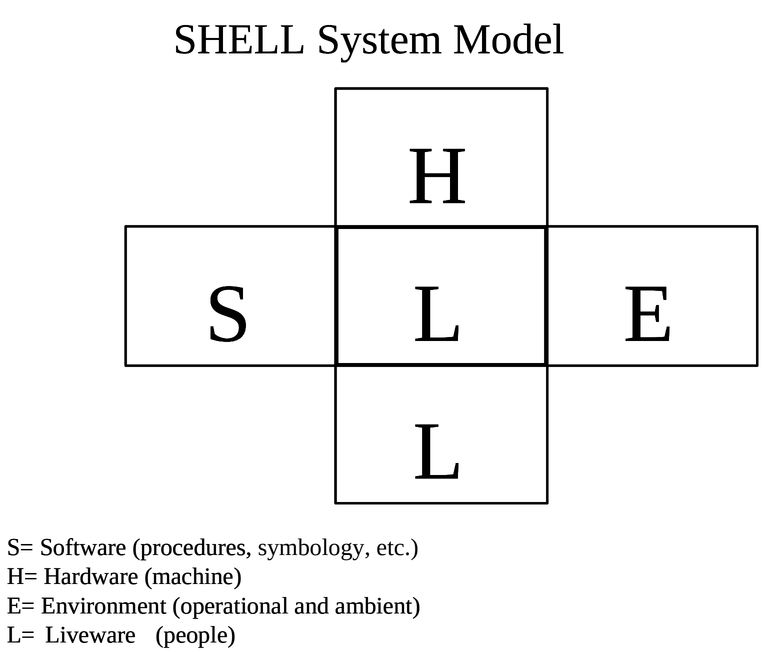


Figure 4.7-3. Depiction of SHELL Interface Model

4.7.1.2.1 Functional Interfaces

Functional interfaces define the purpose of the interface. Each interface has at least two associated functions, and, because all performance requirements are traceable to functions, there shall be at least two associated interface requirements. This concept is illustrated in Figure 4.7-4, where Side A delivers some quantity (e.g., electrical power) to Side B; at the same time, Side B receives that quantity from Side A. The two implied requirements are:

- Side A shall generate the quantity
- Side B shall provide a compatible response to the quantity that Side A delivered

Interface requirements shall be expressed in verifiable terms. For example, as expressed in strict requirements terminology, "the [Side A] subsystem shall deliver electrical power at 28 volts." In this example, the element of Side B is a fan. Thus, the requirement for Side B might be as follows: "The fan [Side B] shall provide impedance, power level and timeline, while using the 28-volt power supply of the electrical system [Side A]." The interface definition includes the data and/or control functions and the way these functions are represented.

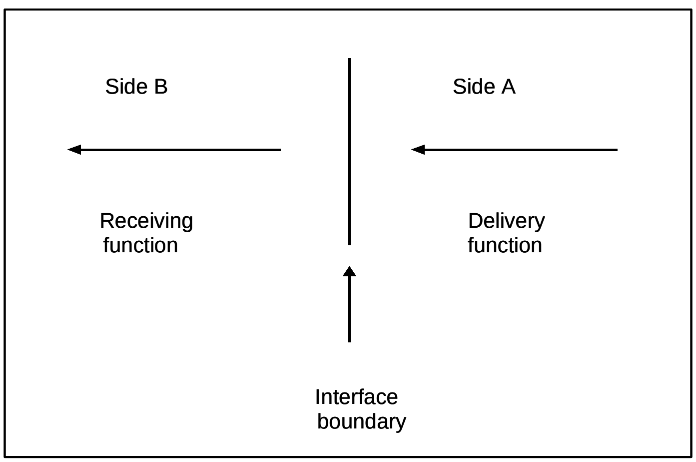


Figure 4.7-4. Example of a Simple Interface

4.7.1.2.2 Physical Interfaces

Physical interfaces are used to define and control the features, characteristics, dimensions, and tolerances of one design that affects another. Physical interfaces include material properties of the equipment that affect the functioning of mating equipment. They also include the operating environment of the system.

4.7.2 Inputs to Interface Management

The inputs required to initiate Interface Management include both program/project- and product-related data listed in Table 4.7-2. Many of these inputs are developed and refined through the continuous, iterative processes of other SE elements.

Table 4.7-2. Interface Management Process Inputs

Input	Reference
CONOPS	Functional Analysis (Section 4.4)
Architecture	Synthesis (Section 4.5)
Requirements MNS/iRD	Requirements Management (Section 4.3)
International Standards	System Engineering in the Acquisition Management System Program Lifecycle (Chapter 3)
FAA Order/Standards	System Engineering in the Acquisition Management System Program Lifecycle (Chapter 3)
Functional Analysis	Functional Analysis (Section 4.4)
Draft IPP	Integrated Technical Planning (Section 4.2)
Trade Study Report	Trade Studies (Section 4.6)
Engineering solution actions and impacts	Trade Studies (Section 4.6)
Interface Control Plan	Integrated Technical Planning (Section 4.2)
Interface Change Request	Interface Management (Section 4.7)

4.7.3 Interface Management Process Tasks

The Interface Management process is an integrated and iterative set of activities that ensures that all functional and physical interface requirements are identified, defined, and controlled, including interfaces within the system, as well as those between the instant system and another system. Table 4.7-3 outlines the process. The paragraphs below describe the process tasks.

Table 4.7-3. Interface Management Process Inputs by Output Product

Inputs	Source Process	Initial AMS Phase	Output
Requirements Documents (MNS/iRD)	Requirements Management (Section 4.3)	Mission Analysis (MA)	
CONOPS	Functional Analysis (Section 4.4)	MA	
Architecture	Synthesis (Section 4.5)	MA	
Functional Interface List	Functional Analysis (Section 4.4)	MA	
			Scope Sheet
FAA Policy	External	Investment Analysis (IA)	
Standards	External	IA	
Draft Interface Control Planning section of IPP	Integrated Technical Planning (Section 4.2)	IA	

Inputs	Source Process	Initial AMS Phase	Output
Requirements Documents (fRD)/Changes	Requirements Management (Section 4.3)	IA	
System Requirements/Changes	Functional Analysis (Section 4.4) Synthesis (Section 4.5) Trade Studies (Section 4.6)	IA	
Physical Architecture	Synthesis (Section 4.5)	IA	
Trade Study Report	Trade Studies (Section 4.6)	IA	
			IRD
IRD		Solution Implementation (SI)	
Interface Change Request	External	SI	
Physical Architecture	Synthesis (Section 4.5)	SI	
Design Definition/Changes	Synthesis (Section 4.5)	SI	
Final Interface Control Planning section of IPP	Integrated Technical Planning (Section 4.2)	SI	
			ICD
Interface Revision Proposal			
			Revised IRD/ICD

4.7.3.1 Task 1: Identify Functional/Physical Interfaces

The first task in the Interface Management process is to identify the functional and physical interfaces, which is accomplished via N^2 diagrams. The functional interfaces are identified during the Mission Analysis phase, while the physical interfaces are identified during the Investment Analysis phase.

4.7.3.2 Task 2: Create an N^2 Diagram

The N^2 diagram is a systematic approach to identify, define, tabulate, design, and analyze functional and physical interfaces. It applies to system interfaces and hardware and/or software interfaces. The "N" in an N^2 chart is the number of entities for which relationships are shown. The N^2 diagram is a visual matrix that requires the user to generate complete definitions of all the system interfaces in a rigid bidirectional, fixed framework. In this method, the system functions are placed on the diagonal axis; the remainder of the squares in the N x N matrix represents the interface inputs and outputs. The presence of a blank square indicates that there is no interface between the respective system functions. Data flows in a clockwise direction between functions (i.e., the symbol F1 ↴ F2 indicates data flowing from function F1 to function F2; the symbol F2 ⮥ F1 indicates the feedback). The transmitted data is defined in the appropriate squares. The diagram is complete when each function has been compared to all other functions. The N^2 diagram may be used in successively lower levels down to the component functional level. Figure 4.7-5 is a basic N^2 diagram.

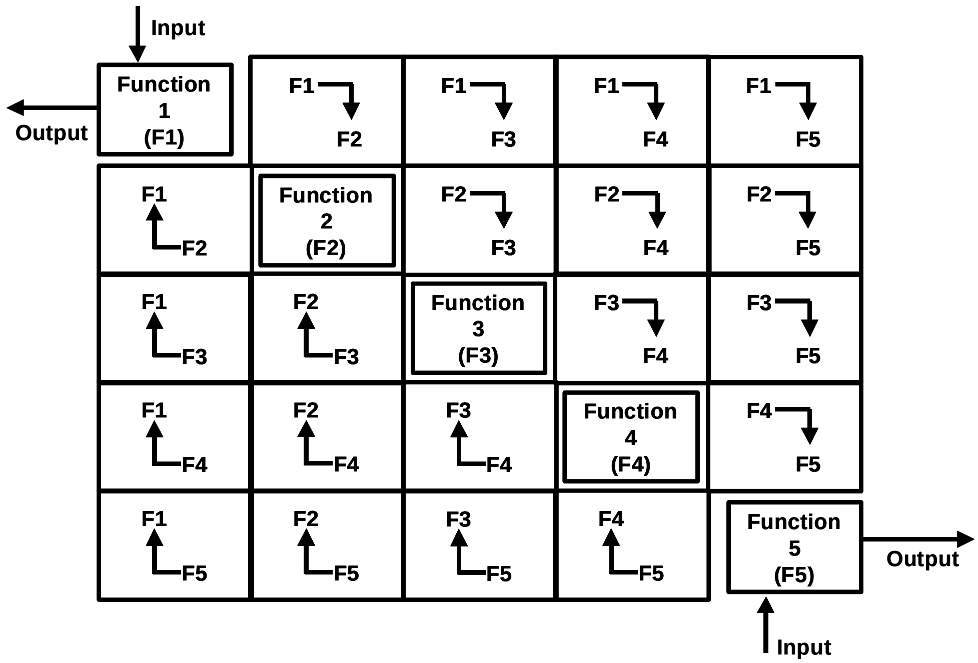


Figure 4.7-5. Generic N^2 Diagram

In the following example, N equals 5. The five functions are listed on the diagonal. The arrows show the flow data between functions. So if function 1 sends data to function 2, an X would be placed in the box to the right of function 1. If function 1 does not send data to any of the other functions, the rest of the boxes to right of function 1 would be empty. If function 2 sends data to function 3 and function 5, then an X would be placed in the first and third boxes to the immediate right of function 2. If any function sends data back to a previous function, then the associated box to the left of the function would have an X placed in it The squares on either side of the diagonal (not just adjacent squares) are filled in with appropriate data to depict the flow between the interfaces (functions). If there is no interface required between two functions, the corresponding square is left blank. Physical interfaces would be handled in the same manner.

In the example below, all data is acquired in function 1. All acquired data is sent to function 2 for storage. However, some acquired data is sent to function 5 to be printed immediately. Therefore, there is an X in the first and fourth boxes to the right of function 1 showing this data flow. All data stored in function 2 can be retrieved by function 3. Function 3 sends the data to function 4 where it is reformatted and then sent to function 5 for printing. Thus, there is an X in the box to the immediate right of function 3 and 4. Since the system needs to save the reformatted data for possible retrieval and printing, there is an X in the box to the left of function 4 intersecting with function 2. However, since there may be a need for reformatted data to be printed at a later date, there is an X in the second box to the right of function 3, which shows the retrieval of reformatted data sent directly to the printer.

The following steps are recommended for creating a functional N^2 diagram:

Step 1: Identify the functional interfaces via an N^2 chart and develop functional interface list.

- Create an N^2 diagram that is N X N square, where N is the number of system functions.
- Place the system functions on the diagram's diagonal axis.
- Moving across the diagram, fill in each square with any output, moving from function F1 to any of the succeeding functions. (Interfaces between functions flow in a clockwise direction.) If there are no outputs to a succeeding function, leave the square blank. (Characteristics of the entity (e.g., data, electrical power) passing between functions may be included in the box where the entity is identified.) Continue in this fashion until the upper half of the N^2 diagram is populated.
- Moving down the diagram, fill in each square with any input, moving from function F2 to function F1, from function F3 to functions F2 or F1, and so on with succeeding functions. If there are no outputs to a succeeding function, leave the square blank. Continue in this fashion until the lower half of the N^2 diagram is populated.
- Conduct a peer review for completeness.

Step 2: Develop a functional interface list from the functional N^2 diagram.

The next action is to identify the physical interfaces via the N^2 diagram during the Investment Analysis phase using the selected Physical Architecture.

Step 3: Identify the physical interfaces via an N^2 chart and develop physical interface list.

- Create an N^2 diagram that is N X N square, where N is the number of system elements.
- Place the system elements on the diagram's diagonal axis.
- Moving across the diagram, fill in each square with any output, moving from system S1 to any of the succeeding systems. (Interfaces between systems flow in a clockwise direction.) If there are no outputs to a succeeding system, leave the square blank. (Characteristics of the entity (e.g., data, electrical power) passing between systems may be included in the box where the entity is identified.) Continue in this fashion until the upper half of the N^2 diagram is populated.
- Moving down the diagram, fill in each square with any input, moving from system 1 to system 2, from system 3 to systems 2 or 1, and so on with succeeding systems. If there are no outputs to a succeeding system, leave the square blank. Continue in this fashion until the lower half of the N^2 diagram is populated.
- Conduct a peer review for completeness.

Step 4: Develop a Physical I/F list from the Physical N^2 chart.

An example of an output from Step 3 appears in Figure 4.7-6. The N^2 diagram shall be taken down in successively lower levels to the hardware and software component levels. In addition to interface identification, another main function of the N^2 diagram is to pinpoint areas where conflicts may arise between systems and functions so that system integration occurring later in the development cycle proceeds efficiently.

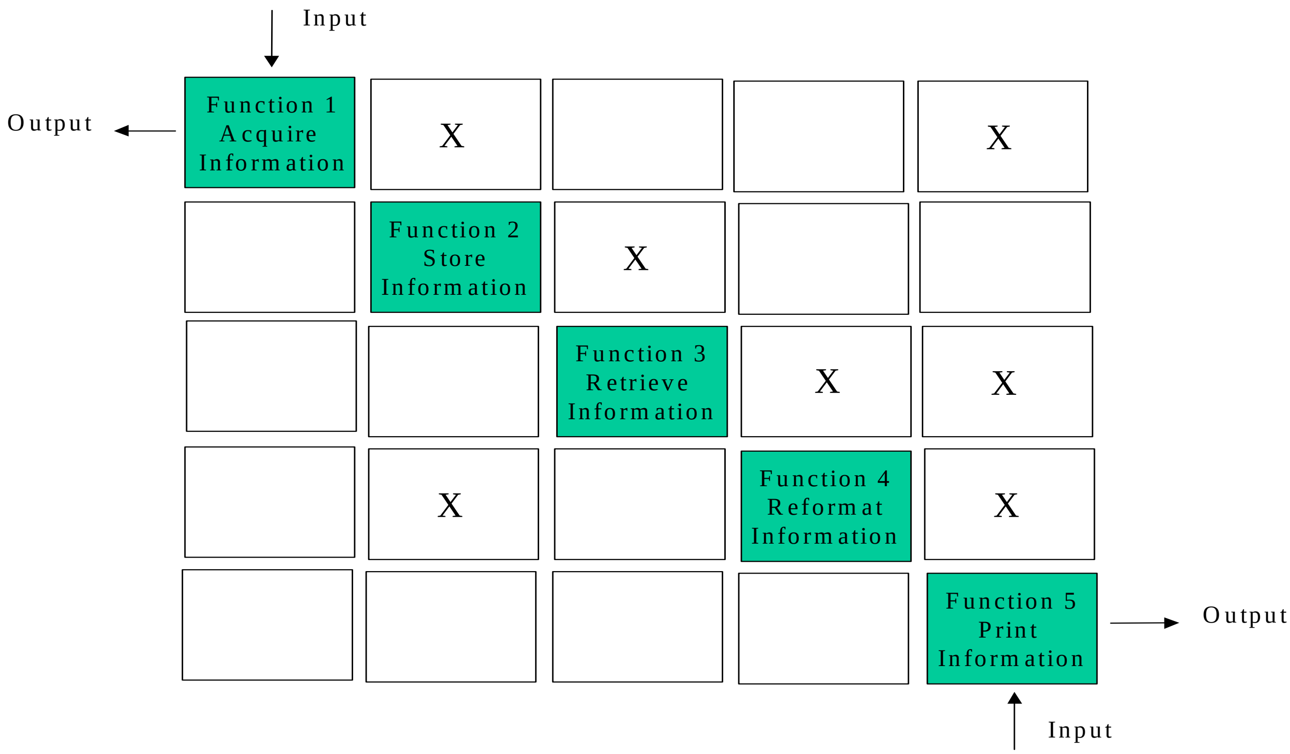


Figure 4.7-6. Example of a Simple N^2 Diagram

4.7.3.3 Task 3: Define Functional and Physical Interfaces To Prepare Scope Sheets

The third task in the Interface Management process is to define the functional and physical interfaces, which is accomplished via scope sheets and IRDs. Scope sheets are used to develop the Interface Control planning section of the Integrated Program Plan (IPP) (Integrated Technical Planning (Section 4.2)). This Interface Control planning section defines a management system of interface controls to ensure physical and functional compatibility between interfacing system elements and between systems. This section also provides the means to identify and resolve interface incompatibilities (through a program management mechanism known as the Interface Working Group (IWG)) and determines the impact of interface design changes. Source material for the Interface Control planning section includes the CONOPS, MNS, iRD and draft IPP. The previously developed N^2 diagrams are used to complete a scope sheet for each interface, which, in turn, is used to write the required IRDs.

The following steps shall be taken when scope sheets are prepared:

- Step 1: Review scope sheet format (Figures 4.7-7 and 4.7-8)
- Step 2: Review functional and physical I/F lists
- Step 3: Prepare a scope sheet for each element in the diagonal, which corresponds to internal interfaces
- Step 4: Review final Requirements Documents (fRD) to determine required external interfaces

- Step 5: Prepare scope sheets for all external interfaces
- Step 6: Enter scope sheets into Configuration Management process (Section 4.11)
- Step 7: Evaluate Scope Change Requests and update scope sheets as necessary

<table>
<tr><td colspan="2">ICD NUMBER:

REV:</td><td colspan="2">DATE INITIATED:

DATE:</td></tr>
<tr><td colspan="2">ICD TITLE</td><td colspan="2"></td></tr>
<tr><td colspan="2">PARTICIPANTS:</td><td colspan="2"></td></tr>
<tr><td colspan="2">SCOPE:</td><td colspan="2"></td></tr>
<tr><td colspan="2">EQUIPMENT RESPONSIBILITY:</td><td colspan="2"></td></tr>
<tr><td colspan="4">INTERFACE LOCATION (INTERFACE BLOCK DIAGRAM)</td></tr>
<tr><td colspan="2">EFFECTIVITY:</td><td colspan="2"></td></tr>
<tr><td colspan="2">PROGRAM REVIEWS & AUDITS:</td><td colspan="2"></td></tr>
<tr><td colspan="4">RELATED ICDs</td></tr>
<tr><td colspan="4">APPROVALS:</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Participant</td><td>Date</td><td>Participant</td><td>Date</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>IWG Secretariat</td><td>Date</td><td>IWG Chairman</td><td>Date</td></tr>
</table>

Figure 4.7-7. Format of Scope Sheet for Interface Management

<table>
<tr><td colspan="2">ICD NUMBER: 25-DR010M
REV: 1</td><td colspan="2">DATE INITIATED: June 25, 3032
DATE: December 6, 3033</td></tr>
<tr><td colspan="2">ICD TITLE</td><td colspan="2">Interface Control – Surveillance Radar Product Generator (RPG) – Weather System Processor (WSP) - Electrical Installation Envelope, Mechanical, Environmental, and Data</td></tr>
<tr><td colspan="2">PARTICIPANTS:</td><td colspan="2">Green Electronics/Lockheed Martin</td></tr>
<tr><td colspan="2">SCOPE:</td><td colspan="2">This IRD/ICD controls and documents all interface requirements for the RPG to WSP interface. Interface definition is described to the extent necessary to assure compatibility of the RPG to WSP interfacing hardware when used with the specified constraints. The interface consists of mechanical installation of the WSP for cabling, mounting, environmental cooling, and data requirements. Mechanical interfaces include location, orientation, mounting provisions, and power supply. Envelope interfaces include installation, removal, connector, and cable clearances. Environmental interfaces include temperature and humidity constraints. The data interface includes Airport Surveillance Radar (ASR) 27 data (RF, control, data, and timing signals) and WSP data (control and status signals).</td></tr>
<tr><td colspan="2">EQUIPMENT RESPONSIBILITY:</td><td colspan="2">1. Green Electronics – ASR-27 radar product generator
2. Lockheed Martin – WSP module (hardware and software)</td></tr>
<tr><td colspan="4">INTERFACE LOCATION (INTERFACE BLOCK DIAGRAM)</td></tr>
<tr><td colspan="2">EFFECTIVITY:</td><td colspan="2">PK/RG (TYPE VIII)</td></tr>
<tr><td colspan="2">PROGRAM REVIEWS & AUDITS:</td><td colspan="2">WSCE IRR September 3032, WSCE SER December 3032, WSCE PDR March 3033</td></tr>
<tr><td colspan="4">RELATED ICDs</td></tr>
<tr><td colspan="4">APPROVALS:</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Raytheon</td><td>Date</td><td>Lockheed Martin</td><td>Date</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>IWG Secretariat</td><td>Date</td><td>IWG Chairman</td><td>Date</td></tr>
</table>

Figure 4.7-8. Example Scope Sheet

4.7.3.4 Task 4: Develop Interface Requirements Documents

The next task in the Interface Management process is to develop IRDs, which, in turn, are used to develop ICDs. The designated custodian shall prepare the detailed IRD. FAA-STD-025 provides a checklist for IRD and ICD content. Several commonly used FAA standards appear in Table 4.7-4.

The following steps shall be undertaken when IRDs are developed:

- Step 1: Review the inputs listed in Table 4.7-2
- Step 2: Prepare the detailed IRD in accordance with (IAW) FAA-STD-025
- Step 3: Review the IRD for compliance with the fRD
- Step 4: Coordinate the revised draft IRD with all affected organizations
- Step 5: Enter the IRD into the Configuration Management process (Section 4.11)

Table 4.7-4. Checklist for Interface Requirements Document Standards*

(In Accordance With FAA-STD-025)

Standard	Title
FAA-STD-025	Preparation of Interface Documentation
FAA-STD-002	Facilities Engineering Drawing Preparation
FAA-STD-005	Preparation of Specification Documents
FAA-STD-019	Lighting Protecting, Grounding, Bonding, and Shielding Requirements for Facilities
FAA-STD-020	Transient Lighting Protecting, Grounding, Bonding, and Shielding Requirements for Equipment
FAA-STD-023	Microfilming of Engineering and Electrical Drawings
FAA-STD-029	Selection of Telecommunications Standards
FAA-STD-032	Design Standards for National Airspace System (NAS) Physical Facilities
FAA-STD-039	NAS Open Systems Architecture and Protocols
FAA-STD-042	NAS Open System Interconnection (OSI) Naming and Addressing
FAA-STD-043	NAS OSI Priority
FAA-STD-044	NAS OSI Directory Services
FAA-STD-045	NAS OSI Security Standard
FAA-STD-047	NAS OSI Conformance Testing
FAA-STD-048	NAS OSI Interoperability Testing
FAA-STD-049	FAA Standard for Fiber Optic Telecommunications Systems and Equipment
FAA-STD-060	FAA Standard for Data Standard for National Airspace System (NAS)
FAA-G-2100	Electronics Equipment, General Requirements
MIL-STD-005	Engineering Drawing Practices

Standard	Title
ISO 8648-1988	Information Processing Systems – OSI Internal Organization of the Network
ISO/IEC 96467:1998	Information Technology – OSI – Conformance Testing Methodology and Framework: Implementation Conformance Statements
ISO/IEC TR 1000-1-1998	Information Technology – Framework and Taxonomy of International Standardization Profiles – Part 1: General Principles and Documentation Framework
IEEE 315 – 1975	Graphic Symbols for Electric and Electronics Diagrams (including reference class designations letters)
ANSI/IEEE 315A –1986	Supplement to Graphic Symbols for Electrical and Electronics Diagrams (supplement to Institute of Electrical and Electronics Engineers, Inc. (IEEE) and standard 315-1975)

*Note: that this is not necessarily a complete list.

4.7.3.5 Task 5: Write Interface Control Documents

During this task, the detailed ICD/Interface Control Notice (ICN) is prepared, and an analysis is performed to confirm completeness and accuracy of the interface definition. These documents shall be reviewed for compliance with the defined scope sheets and coordinated. A record of these actions shall be maintained.

FAA-STD-025 provides a checklist for ICD content.

- Step 1: Review the inputs listed in Table 4.7-2
- Step 2: Prepare the detailed ICD IAW FAA-STD-025
- Step 3: Review the ICD for compliance with IRD
- Step 4: Coordinate the revised draft ICD with all affected organizations
- Step 5: Enter the ICD into the Configuration Management process (Section 4.11)

4.7.3.6 Task 6: Revise Interface Requirements Documents and Interface Control Documents

It may be necessary to request changes to the IRD/ICD as changes to Requirements or design definition occur.

- Step 1: Review the IRD for any required changes when design modifications occur or new requirements are added to the system RD to determine if changes are required.
- Step 2: Review the ICD to determine if changes are also required.
- Step 3: Prepare the change request IAW FAA-STD-025 and provide the following information:
  – Description of the problem and the proposed change
  – Analysis showing how the change solves the problem

  - Analysis of how the change impacts system performance, effectiveness, and lifecycle costs
  - Analysis to ensure that the proposed solution does not introduce new problems
  - Description of resources and an estimate of the costs associated with implementing the change
  - Statement of impact to system

- Step 4: Provide change request to IWG, which shall determine if the authorized Interface Change Request (ICR) is within the scope. In-scope ICRs shall be returned to the ICR originator and the custodian of the IRD/ICD for preparation and release of an interface requirement. Out-of-scope ICRs shall be forwarded to program manager.

- Step 5: Coordinate the draft IRD/ICD with all affected organizations.

- Step 6: Enter the changed IRD/ICD into the Configuration Management process (Section 4.11).

- Step 7: Determine if IRD changes affect the system RD and if so, update RD also.

4.7.4 Outputs of Interface Management

The outputs of the Interface Management process appear in Table 4.7-5. When documented and approved, the IRD is provided to all applicable organizations, while the ICD is provided to technical disciplines responsible for meeting its interface requirements, to customer and program management for coordination, and to the respective test and quality assurances organizations.

Table 4.7-5. Interface Management Process Outputs and Destination SE Element

Outputs	Destination SE Element
IRDs	Requirements Management (Section 4.3) Configuration Management (Section 4.11) Synthesis (Section 4.5) Validation and Verification (Section 4.12)
ICDs	Requirements Management (Section 4.3) Configuration Management (Section 4.11) Synthesis (Section 4.5) Validation and Verification (Section 4.12)
Interface Change Proposal (ICP)	Configuration Management (Section 4.11)

4.7.5 Interface Management Tools

The functional flow diagram (FFD):

- The FFD family is a group of analyses that depicts functional (input-function-output) relationships between functions. This family includes the Department of Defense (DoD) standard FFDs, N^2 diagrams, Integrated Definition for Function Modeling (IDEF) tools, and the Unified Modeling Language (UML). The FFD is a multi-tier, time-sequenced, step-by-step diagram of the system's functional flow. Typically, FFDs are prepared to define the detailed, step-by-step, operational and support sequences for systems, but they may also be used effectively to define processes in developing and producing systems. In this method, the functions are organized and depicted by their logical inputs and outputs. Each function is shown in relation to the other functions by how the inputs and outputs feed and is fed by the other functions. Each function is depicted as a node labeled with the function name. (Naming criteria are described in "Introduction to Functional Analysis" (Paragraph 4.4.1).) Arrows leading into the function depict inputs, while arrows leading out of the function depict outputs. If the output of function F0 is an input to F1, then an arrow is shown leaving F0 and going into F1 ("Functional Flow Relationship" (Figure 4.4-12)).

The N^2 Diagram

- The N^2 diagram (Figure 4.7-5) ensures that all functions identified in the Functional Analyses are reflected in functional interfaces. The N^2 diagram is a systematic approach to identify, define, tabulate, design, and analyze functional and physical interfaces. It applies to system interfaces and hardware and/or software interfaces. The "N" in an N^2 chart is the number of entities for which relationships are shown. The N^2 diagram is a visual matrix that requires the user to generate complete definitions of all the system interfaces in a rigid bidirectional, fixed framework. In this method, the system functions or physical architecture elements are placed on the diagonal axis; the remainder of the squares in the N x N matrix are examined for interface inputs and outputs. The outputs are indicated on the horizontal rows, while the vertical columns indicate inputs. The presence of a blank square indicates that there is no interface between the respective system functions (or physical architecture elements). Data flows in a clockwise direction between functions (i.e., the symbol F1 ↴ F2 indicates data flowing from function F1 to function F2; the symbol F2 ↥ F1 indicates the feedback). The transmitted data is defined in the appropriate squares. The diagram is complete when each function has been compared to all other functions. The N^2 diagram may be used in successively lower levels down to the component functional level.

4.7.6 Interface Management Process Metrics

Table 4.7-6 lists the Interface Management process metrics.

Table 4.7-6. Interface Management Process Metrics

Quality Metrics	Cycle Time Metrics	Cost* Metrics
Scope Sheet in Compliance with Requirements (% “Yes”)	Time from iRD to IRD Approval	Cost to implement IRDs
IRD in Compliance with Requirements (% "Yes")	Time from IRD Approval to ICD Release	Cost to implement ICDs
ICD/Interface Requirement Compliance with Interface Requirements (% "Yes")	Time from ICR Approval to Interface Requirement Release	Cost to implement ICRs
Design Compliance with ICD/Interface Requirement Requirements (% "Yes")		
Number of interfaces discovered after initial release of ICD		

*Note:: Cost is only direct program costs.

4.7.7 Terms and Definitions

Interface Requirements: All interface requirements are classed as functional and physical requirements, as well as constraints that exist at a common boundary between two or more functions, system elements, configuration items, or systems.

IRD: The IRD defines requirements associated with external physical and functional interfaces between the particular system and other associated system(s). The IRD is one of the two basic products of the interface task. In its final form, the IRD is primary documentation of the interface requirements.

ICD: The ICD is one of the two basic products of the interface task. In its final form, the ICD is a “design” document that describes the detailed “as built” implementation of the requirements contained in the IRD. The vendor usually develops it.

Interface Control Planning Section of IPP: The Interface Control planning section of the IPP documents the formal management system of interface controls that ensures physical and functional compatibility between interfacing hardware, software, and facilities. (Integrated Technical Planning (Section 4.2) provides detailed instructions on this topic.)

IWG: The IWG is established through the IPP (and System Engineering Management Plan (SEMP)). The IWG is the forum for discussing interface issues. IWG meetings serve two purposes: to ensure effective, detailed definition of interfaces by all cognizant parties, and to expedite baselining of initial IRDs, ICDs, and subsequent drawing changes by encouraging resolution of interface issues. The IWG shall consist of IWG Chair, IRD/ICD Custodian(s), and management personnel from associated teams. (Integrated Technical Planning (Section 4.2) provides detailed instructions on this topic.)

4.7.8 References

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